This text should be considered as a rough draft. Being far from an essay it is mostly a collection of my thoughts on the subject. I will organize it in correct format with correct referencing in the next step.

Future of Human-Computer Interfacing

On my trimester thesis, I will be analyzing the existing human-computer interfaces and theorize on the new technologies that may be presented to us in near future. The theories will be based on the current advances on the field, will be backed up by recent researches and experiments regarding the subject.

My main questions are:

- Since the beginning of the computer age, through which steps did our interface designs passed?
- What is the limitations of the current interface technologies we have?
- Did we limit these interface designs with the limitations of the days technology?
- Should we focus on designing “natural interfaces” or should we focus on designing “abstract interfaces”.
- If a better design possible, if we could increase the bandwidth of the human-computer communication protocols, could our brains evolve to catch with it? Will we be left behind? Can our brains adapt such situation?

The Approach:

In order to understand the interfaces, I find it suitable to analyze them in two main category. Since these two categories are technologically and conceptually different, on my opinion they shouldn't be mixed.

- Human to computer data transfer. (Output -logically, I take the human as the primary device-)
- Computer to human data transfer. (Input)

Human to computer data transfer - Output:

If we take a look at the electronic interfaces of the past, we see lots of buttons, complex switch arrays and occasionally potentiometers. Did we know the existence of such interaction techniques before they get invented by individual developers and get presented to us? Isn't it an abstract situation to press a button to give a command for the computer? Where did this idea come from?

At the matter of fact, we indeed knew the existence of such concept. The “button” and “switch” concepts has been invented and introduced to the human kind far before the rise of electronic devices. We used to open the lid of a gas lamb with a switch like design. We designed guns with switches and buttons. Even our doors, clocks and many other devices had some sort of switches and mechanical levers. The need for such switches and buttons was to trigger a mechanic structure by applying a physical force. Most of these devices did not have any power source (opening and closing lids and compartments), and the power source was our body. In some cases the device didn't have any way to start the motion (like a gun, clock or first cars) and we needed to provide this energy with our body, simply by using a switch, button or turn a crank.

As the humans get used to these kinds of interaction with the mechanical systems, it was inevitable to base our new and fast growing electronic technology on these pre-learned interaction techniques. It is the nature of the human, due to our hunger to experience these new devices, discover the potential of this new world of computation, we simply did not pay any attention on developing a new way to interact with them. We simply re-used the old and usual way. This situation caused our technology to evolve based on these interaction methods. Maybe we are even limiting our computer technologies with this reason.

Yet, as our technology evolved, we have started to experiment on the new ways of interacting with the computers. As our technology is much more advanced than before, we had the opportunity to design much more complex yet much better interfaces. The first way of doing this was simply making the interfaces more natural. You don't need to learn anything, just touch to the screen like you would do with an object on your desk and it will act as a real object. Or swing the controller like a real tennis racket to hit the ball in a virtual game. Imagine your computer interface as a physical environment. This is an easy to use, yet limited way to interact with the computers, since the virtual world is an abstract environment and we are interacting with it like we do in the real world. In my opinion, this kind of interaction lowers the bandwidth between human and the computer.

Examples of these devices:

- Touch screen interfaces (smartphones, tablets)
- Nintendo Wii
- Xbox Kinect

If you have ever used these devices, you will see that the only way of using them is playing limited games and doing simple tasks. Despite Steve Jobs saying that iPad will destroy the laptops, it is obvious that iPad can only be used for simple tasks. Completing complex tasks, like authoring, programming and even typing is much slower when we compare it with the classic mouse and keyboard combination.

The cyber space has endless possibilities, yet the meat space (real world) is very limited and depending on the laws of physics. Are we sure we want to create another real world while we already have one?

Another way of doing a new interface is by directly using our brains. As the result of many research on this field, we know that our brains have the capability to understand and process tasks far beyond the physical world. We know that it is flexible and capable of understanding the principles of the abstract structure of the cyber space.

In an experiment, researchers has successfully created the very first cyborg that has been built by the human race[1]. The first experiment was about placing rat neurons on an electrical grid, which acts as the interface and connecting this to a specially designed flight simulation program. As the result, the neurons formed a structure which is capable of flying a plane, in a virtual world. This is how flexible our brains are. The following application of this technology was creating a neural network -again with rat neurons- to control a simple robot that uses infrared range finders as input and wheels as output. After some training, the neural network succeeded on controlling the robot by responding to the obstacles on its way[2].

No matter how sci-fi controlling a computer with your mind sounds, even now, there are a couple of brain to computer interfaces that are commercially available. These devices are called Neural Impulse Actuators. The most advanced model on the market is the Emotiv Headset[3].

With Emotiv, you can record certain thoughts and define them as a control that will be given to the computer. Since this is a new technology, the device is still limited to be able to used on daily computer usage.

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1 - http://www.newscientist.com/article/dn6573-brain-cells-in-a-dish-fly-fighter-plane.html

2 -http://www.reading.ac.uk/about/newsandevents/releases/PR16530.aspx

3 -http://www.emotiv.com/

Lets focus on the possible future of brain-computer interface. Lets call this specific type of interface the “abstract interface”, since it doesn't need a natural way to control the devices, the controls themselves could be abstract thoughts. Just like we think certain thoughts without using any keyword, our minds might be able to give computational commands by abstract thoughts.

Lets analyze a simple task that is being done by a standard computer user. We assume the user is using his “own” computer, a structure organized by him. Also we can assume he is using Windows, to be more specific. This task simply could be “opening a browser based mail inbox”, like gmail.

When we decide to check our mail, since this is a common job we do every day, a memory -to be more specific, a neural network specially formed to complete this task- awakens. A chain reaction of complex instructions starts running. We first fetch the location of the browser icon, and decide the best way to reach it. Desktop or programs menu? When the decision is done, we order our arm to take control of the mouse, we move the mouse accordingly and roll over the icon. We order our fingers to double click. Once the browser is opened, we pick the address bar with mouse and type in the address www.gmail.com and press enter. The login interface gets shown and we repeat similar actions to login and see the inbox.

When we analyze the process this way, it sure looks complex. Yet because of the knowledge we know, and the neural networks we form in our mind to do this action queue, it feels like a simple task. What would happen, if we could see our inbox, at the moment we decide to see it? A simple abstract thought of seeing our mails could be observed by a brain to computer interface and could complete the very same task, with less neural and physical activity, leaving space for doing more tasks at the same time.

This situation also applies in programming. While programming, we need to create a structure that will result with a specific software. First the programmer creates this structure in his mind, and transfers it to the computer by a very low bandwidth protocol; The keyboard. What if we could simply transfer this structure in our minds directly to the computer? Wouldn't this increase the productivity speed of human race greatly?

Would controlling computers directly with our minds result as the computers turn into a natural extension of our body, our mind?

For example, if someone loses one of his limbs, the brain still assumes that the limb is still connected to the body. The neural network that has been formed before still tries to control the specific limb. Which creates a situation called Phantom Limb[1]. Which means, the brain may be capable of controlling a non-existing limb. Which may be linked to giving commands to a computational device at a very primitive level.

At the University of Pittsburgh, researchers have managed to use a similar principle to create a gigantic robotic arm, that a monkey can control directly by his brain [2]. After a while, the monkeys brain has evolved in order to control the arm very precisely. Eventually the monkey was able to do very complex maneuvers and tasks with an arm that was not hard-coded in his mind. His mind adapted to the situation. This might be a clue on designing such interfaces.

Human to computer data transfer – Input:

Currently the most common way to receive an input from the computer is using screens and speakers. I will simply focus on the screens, since it is the main way of receiving information from the computer. With the screens, we simulate a real window that projects visual structures that will later be deciphered in our mind to form understandable information. We again, try to simulate the nature on a computational structure. Our eyes are evolved to observe and analyze 3d spaces. They are perfectly optimized for this job, but are they enough to interact with a computer? Is receiving an information through a visual representation of the calculations that has been happening within the computer enough? What would happen if we find a way for the computers to directly transfer data into our brains? Would we "feel" the computer itself, the cyber space?

This is technically a rather more complex subject then reading information from our minds. Our neural networks work quite different than a computer does. In order to

1 http://en.wikipedia.org/wiki/Phantom_limb

2http://spectrum.ieee.org/automaton/robotics/medical-robots/060210-monkey-controls-advanced-robot-using-its-mind

be able to write certain information directly into our brains, we first need to understand how to create logical neural chains and networks which will result with a specific thought that is successfully being observed by the rest of the brain.

Although there are certain advances in neuroscience on this subject that gives us hope, it looks like we will need to wait for a long time for such stable technology to be invented.

In the meanwhile, we could simply start by removing the screens. We can now, install silicon chips and stimulate the retinal nerve cells to create a simulated vision that will be successfully processed by our brains. A group of researchers at the California Institute of Technology managed to execute this technology[1]. With this technology, we could create a screen in our minds in future. As this wouldn't solve the problem expressed above, it may be a new way receiving an input from the computer. We could add artificial interfaces in our regular vision to improve our daily lives with the help of our computers.

Also, this may be a new way to create surrogate type robots, robots that we completely control with our minds and share our vision with. We could merge with the computer itself and do tasks that the fragile human body can't handle.

At the next level, my opinion is that we should focus the existing deciphering systems embedded in our body in order to transfer a certain information to our brain. Our brains have certain lobes that is assigned to do certain functions, but every individual has a different neural network structure. Yet our input devices -sensors- are much more similar and works with the same principles.

Directly manipulating the neurons might not be the easiest way to do write data. By using the existing input systems like our retinal nerve cells, or other nerves that is constantly transmitting data into our brains, we might find a weak point, a bug, or a security opening that might enable us to transfer more data than the naturally intended amount and variety. Who knows, maybe we can transfer entire thoughts by using our retinal nerves, which would work universally with each individual.

1 http://www.sciencedaily.com/releases/2009/10/091019163025.htm